Irradiated Materials Performance

Performance of fuels and structural materials that have been irradiated in nuclear reactors can be studied in Argonne's Energy Technology Division and the Electron Microscopy Center of the Materials Science Division. Unique expertise has been gained during 40 years of developing fuels and structural components for a variety of nuclear reactors, including light water reactors, research and test reactors, fusion tokamaks, liquid-metal-cooled reactors, and space power and propulsion reactors. A full spectrum of programs is conducted, ranging from designing and manufacturing in-reactor experiments, conducting irradiation, performing detailed postirradiation characterization and testing, and evaluating materials performance in service and in postservice interment within a repository. Research results have led to the development and refinement of materials and components to satisfy a broad range of functional requirements and to assess of the capabilities of current and future generations of reactor fuels and materials.

Facilities and Capabilities

The three principal facilities are the Advanced Materials Fabrication Facility (AMFF) for development and fabrication of fuels and components, the Alpha-Gamma Hot Cell Facility (AGHCF) for characterizing and testing irradiated fuels and α-contaminated materials, and the Irradiated Materials Laboratory (IML) for processing and testing α-free structural materials. The AMFF has a wide range of manufacturing and fabrication capabilities, including arc melting, extrusion, hot and cold isostatic pressing, rolling, drawing, and welding. The AGHCF contains mensuration and examination capabilites and precision furnace systems for subjecting materials and components to simulated "off-normal" reactor conditions, including loss-of-coolant accidents. The AGHCF also has a well-equipped analytical electron-beam laboratory that consists of a shielded electron microprobe, a scanning electron microscope, and a scanning Auger microprobe, all fuel-capable. The IML contains a remotely-operable electric discharge machine for preparing precise test specimens from irradiated materials; tensile and creep-rupture testing systems; an instrumented Charpy-impact testing machine, a fracture toughness system and a slow-strain-rate tensile testing system for determining susceptibility to stress corrosion cracking in controlled water chemistry. The three facilities are supported by a "hot shop" for machining low-level mechanical test specimens, and by the Electron Microscopy Center, with its 1.2-MeV electron microscope and high-resolution analytical microscope. (See details on reverse side.)

Accomplishments

- Characterization of high-burnup fuels and cladding from commercial LWRs.
- Characterization of Department of Energy spent nuclear fuels and development of methods for spent-fuel stabilization.
- Development of V-base alloys for fusion first-wall/blanket applications and determination of effects of neutron damage and helium generation on these alloys.
- Investigation of tensile properties of irradiated stainless steels.
- In-reactor and in-cell testing of cladding breaching thresholds for reactor fuels.
- Rapid-turnaround component failure analysis for nuclear utilities.
- Investigation of irradiation-assisted stress corrosion cracking in reactor steels.
- Examination and evaluation of Three Mile Island core and structural material debris.
- Development of U-Pu-Zr fuel for the Integral Fast Reactor.

Irradiated Materials Performance: Facilities and Equipment

Advanced Materials Fabrication Facility

- Alloy preparation and casting (arc and induction melting, powder metallurgy).
- Secondary fabrication (extrusion, rolling, pressing, swaging, drawing, heat treatment).
- Assembly and welding (electron-beam, helium-arc, TIG, laser).
- Inspection (metallography, X-ray radiography).

Alpha-Gamma Hot Cell Facility

- High-purity nitrogen-atmosphere kilocurie hot cell capable of handling articles up to 6 ft long and ≈4 in. in diameter.
- Shielded inert-atmosphere gloveboxes.
- Contaminated Materials Laboratory for preparing and examining low-activity samples.
- Optical metallography with microhardness capability.
- Physical mensuration equipment.
- Gamma spectroscopy.
- Fission-gas collection and analysis.
- Computer-controlled furnaces for controlled heating cycles up to 1400°C.
- Tensile and compression testing capability.
- Leco hydrogen determinator.
- Shielded electron microprobe for quantitative analysis.
- Scanning electron microscope with quantified energy-dispersive X-ray capability (up to 10 R/hr sample activity at contact).
- Scanning Auger electron microprobe (up to 10 R/hr sample activity at contact).

Irradiation Materials Laboratory

- Air-atmosphere, centicurie beta/gamma facility with four individual cells.
- Remotely operable electric discharge machine for preparing precise test specimens from irradiated materials.
- Tensile and creep-rupture testing under vacuum or inert atmosphere, up to 800°C.
- Slow-strain-rate tensile testing up to 320°C in controlled water environment.
- Fracture toughness testing up to 320°C in controlled water environment.
- Instrumented Charpy-impact testing (drop-weight system) to -190°C.

Electron Microscopy Center (Materials Science Division)

- Kratos Em-7 high-voltage electron microscope (1.2 MeV).
- JEOL 100CX-II scanning transmission electron microscope (100 KeV).
- Vacuum Generator Co., HB – 03 field-emission-gun advanced analytical electron microscope.

Contact: Ms. Terri Bray, Manager, Irradiation Performance Section, Energy Technology Division, Argonne National Laboratory, 9700 S. Cass Ave., Argonne, IL 60439-4838. 630-252-9957; Fax: 630-252-9232, email: tbray@anl.gov

05/30/01